COURSE SYLLABUS

Academic year 2024-2025

1. Programme Information

1.1. Higher education institution	Lucian Blaga University of Sibiu
1.2. Faculty	Faculty of Engineering
1.3. Department	Department of Computer Science and Electrical and Electronics Engineering
1.4. Field of study	Computer Science and Information Technology
1.5. Level of study[1]	Master
1.6. Programme of study/qualification	ADVANCED COMPUTING SYSTEMS

2. Course Information

2.1. Name of course	Evolutionary computing			Code	ACS.303.RO
2.2. Course coordinator	Prof. dr. ing. Adrian FLOREA, PhD				
2.3. Seminar/laboratory coordinator	Şef lucr. dr. Ing. Radu CHIŞ				
2.4. Year of study[2]	2	2.5. Semester[3]	3	2.6. Evaluation form[4]	E
2.7. Course type[5]	O	2.8. The formative category of the course[6]			R

3. Estimated Total Time

3.1. Course Extension within the Curriculum – Number of Hours per Week					
3.1.a. Lecture	3.1.b. Seminar	3.1.c. Laboratory	3.1.d. Project	3.1.e. Other	Total
2		2		0	**4**
3.2. Course Extension within the Curriculum – Total Number of Hours within the Curriculum					
3.2.a. Lecture	3.2.b. Seminar	3.2.c. Laboratory	3.2.d. Project	3.2.e. Other	Total[7]
28		28		0	**56**

Time Distribution for Individual Study[8]	Hours
Learning by using course materials, references and personal notes	14
Additional learning by using library facilities, electronic databases and on-site information	14
Preparing seminars / laboratories, homework, portfolios and essays	56
Tutorial activities[9]	6
Exams[10]	4
3.3. Total Individual Study Hours[11] *(NOSI_{sem})*	**94**
3.4. Total Hours in the Curriculum (*NOAD_{sem}*)	**56**
3.5. Total Hours per Semester[12] (*NOAD_{sem}* + *NOSI_{sem}*)	**150**
3.6. No. of Hours / ECTS	**25**
3.7. Number of credits[13]	**6**

4. Prerequisites (if needed)

4.1. Courses that must be successfully completed first (from the curriculum)[14]	Basic (undergraduate) courses in informatics (programming, algorithms) and mathematics (statistics).
4.2. Competencies	

5. Conditions (where applicable)

5.1. For course/lectures[15]	*Board, video projector, flipchart, specific teaching materials, online platforms*
5.2. For practical activities (lab/sem/pr/app)[16]	*Computing technology, software packages, online platforms*

6. Specific competencies acquired[17]

			Credits distribution by competencies[19]
		Number of credits assigned to the discipline[18] — 6	
6.1. Professional competencies	PC13	develop open source software	1
	PC25	designs prototypes	0.5
	PC26	designs control systems	1
	PC27	publishes academic research papers	1
	PC28	performs data analysis	0.5
	PC29	write scientific publications	0.5
6.2. Transversal competencies	TC2	manages personal development	0.5
	TC3	takes responsibility	0.5
	TC4	works in teams	0.5

7. Course objectives (resulted from developed competencies)

7.1. Main course objective	• Identify the main sources of information. • Critical analysis of theoretical models, ideas and approaches established. • Introduce the main concepts, techniques and applications in the field of evolutionary computation. • Give students some experience on when evolutionary techniques are useful, how to use them in practice and how to implement them with different programming languages.
7.2. Specific course objectives	Evolutionary Computing represents a relatively new research field belonging to Artificially Intelligence. It deals with a range of problem-solving techniques based on principles of biological evolution, such as natural selection and genetic inheritance. The aims of this course are to make students understand the principles, the basic paradigms, techniques, and algorithms of evolutionary computing. Evolutionary models are applied for solving some typical NP-hard problems The course presents algorithms that involve techniques implementing mechanisms such as reproduction, mutation, recombination, natural selection and survival of the fittest. In this course, we will study some basic principles of genetic algorithms, evolutionary programming, evolution strategy, genetic programming and learning classifier systems and swarm intelligence (ant colony and wasp-like models for optimization and particle swarm optimization) as well as new paradigms as membrane computing. In addition, an enhanced attention will be on multi-objective optimization methods and searching techniques.

8. Content

8.1. Lectures[20]		**Teaching methods[21]**	**Hours**
Lecture 1	Introduction to evolutionary computing (EC). Applications of EC. Positioning of EC and the basic EC metaphor. Historical	Exposition, lecture, use of video projector,	2

	perspective. Biological inspiration. Motivations for EC.	discussions with students	
Lecture 2	Basic schema and components / operators of an evolutionary algorithm (EA): Representation / Evaluation / Population / Parent Selection / Recombination / Mutation / Survivor Selection / Termination. Application of EC in optimization.	Exposition, lecture, use of video projector, discussions with students	2
Lecture 3	Informed1 search strategies (heuristics): Global Search Algorithms (Best first search – Greedy, A*) and Local Search Algorithms (Hill Climbing, Simulated Annealing, Tabu Search).	Exposition, lecture, use of video projector, discussions with students	2
Lecture 4	Genetic algorithms. Representations, mutations, crossovers, selection mechanisms. Examples. Memetic algorithms.	Exposition, lecture, use of video projector, discussions with students	4
Lecture 5	Holland's Schema Theorem. Schema Fitness, Schema Disruption, Schema Survival. Landscape Metrics. Stochastic analysis techniques. Markov Chain Analysis. Examples.	Exposition, lecture, use of video projector, discussions with students	2
Lecture 6	Evolutionary strategies. Theoretical Aspects. Algorithm. Representation and operators. Characteristics. Examples (1+1), (μ+1), (μ+λ), (μ,λ).	Exposition, lecture, use of video projector, discussions with students	2
Lecture 7	Midterm Review from taught lessons.	Board presentation of the studied topic, discussions with students	2
Lecture 8	Particle Swarm Optimization. Characteristics. Applications. Examples.	Exposition, lecture, use of video projector, discussions with students	2
Lecture 9	Red Deer Algorithm and Grey Wolf Optimization Algorithm. Characteristics. Applications. Examples.	Exposition, lecture, use of video projector, discussions with students	2
Lecture 10	Pareto optimality. Non-Pareto Classification Techniques (Weighting Method, Lexicographic Order Method, Vector Evaluated Genetic Algorithm etc). Multi-objective optimization methods: Multi-objective Genetic Algorithm (MOGA), Non-dominated Sorting Genetic Algorithm (NSGA), Strength Pareto Evolutionary Algorithm (SPEA), Pareto Archived Evolution Strategy (PAES).	Exposition, lecture, use of video projector, discussions with students	2
Lecture 11	Methodological aspects in working with EA. Quality Indicators useful in multi-objective optimization techniques. Experiment design. Algorithm design. Testing and validation problems. Using jMetal library (http://jmetal.sourceforge.net/index.html) make comparisons between Evolutionary Algorithms previously discussed.	Exposition, lecture, use of video projector, discussions with students	2
Lecture 12	Hybrid Evolutionary Algorithms: EA assisted by Neural Networks, EA assisted by Ant Colony Optimization, Evolutionary Algorithms assisted by Particle Swarm Optimization, Fuzzy Logic assisted Evolutionary Algorithms, Evolutionary Algorithms assisted by Bacterial Foraging.	Exposition, lecture, use of video projector, discussions with students	2
Lecture 13	Final Review from taught lessons.	Board presentation of the studied topic, discussions with students	2
		Total lecture hours:	**28**

[1] Se bazează pe informații (disponibile) specifice problemei încercând să restrângă căutarea prin alegerea inteligentă a nodurilor care vor fi explorate.

8.2. Practical activities (8.2.a. Seminar[22]/ 8.2.b. Laboratory[23]/ 8.2.c. Project[24])		**Teaching methods**	**Hours**
Act.1	Lindemayer Grammars-models for biological evolving systems	Practical demonstration, exercise	2
Act.2	Overview of Genetic Algorithms application in diverse area of fields: Aerospace engineering, Astronomy and astrophysics, Electrical engineering, Financial markets, Game playing, Mathematics and algorithmic, Molecular biology, Pattern recognition and Data mining, Robotics, Routing and Scheduling, Systems engineering. Presenting the practical assignment and organizing the teams for implementation.	Practical demonstration, exercise	4
Act.3	Representation methods for data encoding in genetic algorithms.	Practical demonstration, exercise	4
Act.4	Selection methods in genetic algorithms implementation.	Practical demonstration, exercise	2
Act.5	Methods of change for genetic algorithms: Crossover and Mutation	Practical demonstration, exercise	2
Act.6	Apply evolutionary techniques to optimize the target imposed. Implementation of algorithms and methods in code.	Practical demonstration, exercise	10
Act.7	Each team will deliver a technical report (TR), code and PowerPoint presentation (PPT) in which will present the strategy used. Based on the TR it will be developed a scientific paper.	Practical demonstration, exercise	4
		Total seminar/laboratory hours:	28

9. Bibliography

9.1. Recommended Bibliography	http://webspace.ulbsibiu.ro/adrian.florea/html/Planificari/Planif_EvolutionaryComputing_ACS_2.pdf
	A.E. Eiben, J.E. Smith, Introduction to Evolutionary Computing, Springer, 2003.
	Adam Marczyk, Genetic Algorithms and Evolutionary Computation, 2004 http://www.talkorigins.org/faqs/genalg/genalg.html .
	John R. Koza, Genetic Programming: On the Programming of Computers by Means of Natural Selection (Complex Adaptive Systems), The MIT Press, 1992.
	Carlos A. Coello Coello, David A. Van Veldhuizen, Gary B. Lamont, Evolutionary Algorithms for Solving Multi-Objective Problems, 2nd Edition, Springer, 2007.
	Crina Grosan, Ajith Abraham and Hisao Ishibuchi, Hybrid Evolutionary Systems, Studies in Computational Intelligence, Springer Verlag, Germany, 2006.
	Neghină, M., Dicoiu, A. I., Chiş, R., & Florea, A. (2024). A competitive new multi-objective optimization genetic algorithm based on apparent front ranking. Engineering Applications of Artificial Intelligence, 132, 107870.
	Pătrăuşanu, A., Florea, A., Neghină, M., Dicoiu, A., & Chiș, R. (2024). A Systematic Review of Multi-Objective Evolutionary Algorithms Optimization Frameworks. Processes, 12(5), 869.
	S.N.Sivanandam, S.N.Deepa, Introduction to Genetic Algorithms, Springer Verlag GmbH; 2007.
9.2. Additional Bibliography	K. Deb, A. Pratap, S. Agarwal, and T. Meyarivan, "A fast and elitist multiobjective genetic algorithm: NSGA-II," Evolutionary Computation, IEEE Transactions on, vol. 6, no. 2, pp. 182-197, 2002.
	E. Zitzler, M. Laumanns, L. Thiele, and others, "SPEA2: Improving the strength Pareto evolutionary algorithm," in Eurogen, pp. 95–100, 2001.
	M. R. Sierra and C. A. C. Coello, "Improving PSO-based multi-objective optimization using crowding, mutation and dominance," IN EMO'2005, PAGES 505–519. LNCS 3410, pp. 505--519, 2005.

	M. Reyes-Sierra and C. A. Coello, "Multi-objective particle swarm optimizers: A survey of the state-of-the-art," International Journal of Computational Intelligence Research, vol. 2, no. 3, pp. 287–308, 2006.

10. Conjunction of the discipline's content with the expectations of the epistemic community, professional associations and significant employers of the specific study program[25]

Students will acquire research skills preparing them for the transition to a new stage of doctoral admission. It is carried out through regular discussions in a formal and informal setting with the representatives of the profile companies.

11. Evaluation

Activity Type	11.1 Evaluation Criteria	11.2 Evaluation Methods		11.3 Percentage in the Final Grade	Obs.[26]
11.4a Exam / Colloquy	• Theoretical and practical knowledge acquired (quantity, correctness, accuracy)	Tests during the semester[27]:	10%	60%	CPE
		Homework:	20%		
		Other activities[28]:	10%		
		Final evaluation:	60%		
11.4c Laboratory	• Knowledge of the equipment, how to use specific tools; evaluation of tools, processing and interpretation of results	• Written questionnaire • Oral response • Laboratory notebook, experimental works, reports, etc. • Practical demonstration		40%	CPE
11.5 Minimum performance standard[29] The final assessment will include written work consisting of (partial) grid tests and problems. • Knowledge, understanding and explaining the basics of evolutionary computing. • Constant interest to acquire discipline. • Partial fulfilment (50%) of homework, essays and tests given during the semester.					

The Course Syllabus will encompass components adapted to persons with special educational needs (SEN – people with disabilities and people with high potential), depending on their type and degree, at the level of all curricular elements (skills, objectives, contents, teaching methods, alternative assessment), in order to ensure fair opportunities in the academic training of all students, paying close attention to individual learning needs.

Filling Date: 10.09.2024
Department Acceptance Date: 16.09.2024

	Academic Rank, Title, First Name, Last Name	Signature
Course Teacher	Prof. Adrian FLOREA, PhD	[signature]
Study Program Coordinator	Prof. Adrian FLOREA, PhD	[signature]
Head of Department	Assoc. Prof. Radu George CREȚULESCU, PhD	[signature]
Dean	Prof. Maria VINȚAN, PhD	[signature]

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[1] *Bachelor / Master*
[2] *1-4 for bachelor, 1-2 for master*
[3] *1-8 for bachelor, 1-3 for master*
[4] *Exam, colloquium or VP A/R - from the curriculum*
[5] *Course type: R = Compulsory course; E = Elective course; O = Optional course*
[6] *Formative category: S = Specialty; F = Fundamental; C = Complementary; I = Fully assisted; P = Partially assisted; N = Unassisted*
[7] *Equal to 14 weeks x number of hours from point 3.1 (similar to 3.2.a.b.c.)*
[8] *The following lines refer to individual study; the total is completed at point 3.37.*
[9] *Between 7 and 14 hours*
[10] *Between 2 and 6 hours*
[11] *The sum of the values from the previous lines, which refer to individual study.*
[12] *The sum (3.5.) between the number of hours of direct teaching activity (NOAD) and the number of hours of individual study (NOSI) must be equal to the number of credits assigned to the discipline (point 3.7) x no. hours per credit (3.6.)*
[13] *The credit number is computed according to the following formula, being rounded to whole neighbouring values (either by subtraction or addition*

$$No.credits = \frac{NOCpSpD \times C_C + NOApSpD \times C_A}{TOCpSdP \times C_C + TOApSdP \times C_A} \times 30\, credits$$

Where:

- NOCpSpD = Number of lecture hours / week / discipline for which the credits are calculated
- NOApSpD = Number of application hours (sem./lab./pro.) / week / discipline for which the credits are calculated
- TOCpSdP = Total number of course hours / week in the Curriculum
- TOApSdP = Total number of application hours (sem./lab./pro.) / week in the Curriculum
- C_C/C_A = Course coefficients / applications calculated according to the table

Coefficients	**Course**	**Applications (S/L/P)**
Bachelor	2	1
Master	2,5	1,5
Bachelor - foreign language	2,5	1,25

[14] *The courses that should have been previously completed or equivalent will be mentioned*
[15] *Board, video projector, flipchart, specific teaching materials, online platforms, etc.*
[16] *Computing technology, software packages, experimental stands, online platforms, etc.*
[17] *Competences from the Grids related to the description of the study program, adapted to the specifics of the discipline*
[18] *From the curriculum*
[19] *The credits allocated to the course are distributed across professional and transversal competences according to the specifics of the discipline*
[20] *Chapter and paragraph titles*
[21] *Exposition, lecture, board presentation of the studied topic, use of video projector, discussions with students (for each chapter, if applicable)*
[22] *Discussions, debates, presentations and/or analyses of papers, solving exercises and problems*
[23] *Practical demonstration, exercise, experiment*
[24] *Case study, demonstration, exercise, error analysis, etc.*
[25] *The relationship with other disciplines, the usefulness of the discipline on the labour market*
[26] *CPE – Conditions Exam Participation; nCPE – Does Not Condition Exam Participation; CEF - Conditions Final Evaluation; N/A – not applicable*
[27] *The number of tests and the weeks in which they will be taken will be specified*
[28] *Scientific circles, professional competitions, etc.*
[29] *The minimum performance standard in the competence grid of the study program is customized to the specifics of the discipline, if applicable*